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Nutritive assessment of sorghum-*ogi* plantain flour weaning food

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Abstract. The high rate of malnutrition in children is exclusively attributed to non-affordability of nursing mothers from low-income population to meet the high prices of commercial weaning foods. This has largely affected the dietary status of infant when they reach weaning stage. In this study, utilisation of plantain flour (*Musa spp.*) for enhancing the nutritive value of Sorghum-*Ogi* as common weaning food in southwest Africa was investigated. Same quantity of 100 g/g of Sorghum-*Ogi* was prepared for each of the batches with increasing quantity of plantain flour at 20, 40, 60, 80 and 100% levels of addition to prepare the study samples. Proximate analysis, functional properties, pasting and organoleptic properties, microbial load of the samples were determined using the AOAC official methods for nutritional labelling. Results of proximate analysis showed decreased protein (10.28 – 6.13%), carbohydrate (40.37-7.55%) and ash (1.4-0.3%) contents with increased level of plantain flour addition, while the fat and crude fibre contents increased with increased addition of plantain flour. The functional analysis indicated 28.6% increase in water absorption value at 60% enhancement with decreased value at 100% addition. The microbial load of the blend showed that the food blends are safe for consumption at all level and the organoleptic evaluation by trained panellist preferred 60% acceptance rate of enhancement. In conclusion, the nutritional indices analysed specified the use of plantain flour with Sorghum-*Ogi* as weaning food up to 60% level of inclusion to handle the nutritional deficiency in neonates during weaning stage of development.

Keywords: Weaning diet, Plantain flour *Musa spp.*, malnutrition, organoleptic assessment, infant, proximate evaluation.

1. Introduction

Less nutritious weaning foods, poor weaning nourishments and unhygienic weaning homes predispose neonates to contaminations, diseases, high mortality and malnutrition. Neonates who are adequately breastfed within the first six months are able to sustain adequate growth rate, but after this period, there is need for increase in food intake nutrients to uphold the constant growth hence, the need for nutritive weaning foods. Lack of appropriate nutritive weaning foods lead to malnutrition which has become one of the causes of high mortality rate in infants and this is paramount in the Sub-Sahara part of Africa. Malnutrition is the insufficiency of essential nutrients, which are needed for proper growth and development in diets. Non-availability of certain micronutrients which include iron, zinc and vitamins increases the vulnerability of infants to infections. According to the United Nations Children's Fund [1], children under the age of 5 years accounted for 25 per cent of the 5.4 million deaths in 2017, while neonates accounted for 47 per



cent. In high income countries with about 15 per cent while an average under-five mortality rate of 69 deaths per 1,000 live births, accounted for 29 per cent of all under-five deaths in low-income countries.

Pandey, Choe, Luther, Sahu and Chand [2] reported that till date, 63 out of each 1000 children conceived in India died before attaining the age of one. Most of these children usually die of incurable diseases, which were mostly associated to malnutrition. Some of the major contributors to malnutrition includes and not limited to inadequate of nutritive foods; problems absorbing nutrients from food; poverty; bad mobility; and inadequate food distribution. Malnutrition in neonates can cause some health defects such as Marasmus, Kwashiorkor, Oedema and untimely death. According to the Food and Agriculture Organization, approximately 80% of malnourished children live in nations that have food surpluses but the high prices make the less privileged not to have access to the foods. Malnutrition can also be as a result of health issues such as gastroenteritis, and chronic illness like HIV/AIDS pandemic [3].

Weaning-age malnutrition can also be caused by complementation of breast milk with cereal gruels that are low in essential nutrients [4]. In Nigeria, most nursing mothers introduce weaning food to their neonates at three to six months of age. A readily affordable type of this weaning food is *Ogi*, which is the gruel obtained from fermentation process of Maize, millet or guinea corn. Sorghum, also known as guinea corn, is one of the essential cereals in Africa and is a common staple food in Nigeria. The moisture content of sorghum seed is 8-12% depending of the circumstance during the storage and maturity period [5]. Several researchers [6], [7] and [8] have worked on the fortification of food blends to produce an alternative nutritive and less expensive weaning food from naturally available food materials which are different from the sophisticated commercial weaning foods to help curb the malnutrition issue associated with weaning process.

Plantain (*Musa* spp., ABB genome) is plant producing fruit that stay starchy until maturity and require processing prior to use. Plantain production in Africa was estimated at more than 50% of global production, in fact, West and Central Africa contributed 61% and 21% respectively and it is estimated that about 70 million people in West and Central Africa derive more than 25% of their carbohydrates from plantains, which makes it one of the most important sources of food energy throughout Africa. It has found usefulness in food industries for manufacturing of chips, flakes, or be consumed raw (boiled, fried, roasted) and can be dried and powdered. Plantain has high nutritional value, as it serves as source of dietary carbohydrates, vitamins, minerals and is extremely rich in vitamin A and Iron [9] and [10]. Previous researches on plantain formulated it with maize and soybean as food composite to enhance protein content of maize *ogi* for neonates [11] and [12]. This study was conducted to fortify, improve and assessed the nutritive value of Sorghum-*Ogi* food using plantain flour alone as blend.

2. Materials and Methods

2.1. Materials

Sorghum grain was purchased at Mushin market, Lagos State, which is latitude 6°31' N and longitude 3°20' E, Nigeria and freshly packaged plantain flour was obtained from Covenant University farm, Ota, Ogun-State, Nigeria. The samples were certified at IITA, Ibadan, Nigeria.

2.2. Methods

2.2.1. Preparation of sorghum-*Ogi* (dry basis). 2.5 kg sorghum grain was cleaned and steeped in 5 litres of tap water for 72 hrs, and was afterward grinded using Eurosonic 5 speed mixer at medium speed for 7 mins, the milled product was thoroughly mixed with 10 litres of tap water and then sieved through 100 nm mesh. The slurry gotten was left to stand for 1 hr for the *Ogi* to settle. The supernatant was decanted and the *Ogi* collected was sieved and dried out in a cabinet dryer at 70°C for 2 days and stored in a well labelled polythene bag.

2.2.2. Preparation of sorghum-Ogi plantain flour meal. 100 g of sorghum-Ogi (dry basis) was mixed with 20, 40, 60, 80 and 100 g of plantain flour (dry basis), while 100 g of sorghum-Ogi was used as control for the experiment (Table 1). The samples were mixed using Eurosonic 5-speed hand mixer with rotating bowl and samples properly labelled and kept in air tight plastic container before analysis.

Table 1. Batch composition of Sorghum-Ogi plantain blends

Sample	A	B	C	D	E	F
Plantain flour (g)	0	20	40	60	80	100
Sorghum-Ogi (g)	100	100	100	100	100	100

2.3. Experimental

Moisture content, crude fat, ash content and total nitrogen by the standard micro-kjeldahl method were determined by AOAC method. Percentage (%) nitrogen was converted to crude protein using 6.25 factor while the carbohydrate content was determined by difference. The pH of the sample blends was measured on Unican model pH meter which had been previously standardized with buffer solutions of pH 4 and 9. Pasting properties were obtained using a Rapid Visco Analyser (RVA- Techmaster, Newport Scientific, Warriewood, Australia). Sensory evaluation by a ten-man panellists comprising of tasters who were familiar with the product was carried out on the sorghum-Ogi plantain porridge batch samples. The assessment was based on a 5-point Hedonic scale for appearance, taste, texture, colour and acceptability. The mineral composition of the blends was carried out by wet ashing method using strong acids and oxidizing agents (HNO_3 and H_2SO_4) and heated for 4 hrs at 350°C in fume cupboard and the resulting solution analysed for specific minerals by Atomic Absorption Spectroscopy (AAS) analytical method.

3. Results and Discussion

3.1. Effects of plantain flour on the proximate analysis of Sorghum-Ogi

Moisture content of food samples determines the microbial growth and stability of the food samples and this affect the shelf life of the food blends. Moisture content is an important parameter in food sample analysis; it helps to determine the durability, food safety and storage conditions. Furthermore, moisture content helps to determine the stability and durability of processed foods. It also affects the physical properties of the samples or products.

The moisture and protein content of the sorghum-Ogi plantain flour blends decreased while the fat content increased with increased quantity of plantain flour (Table 2). This is similar to the reports from studies in which yellow maize-Ogi was supplemented with soybean [13], [14]. Sorghum-Ogi has been fortified with several food materials in order to increase its nutritive value. Fortification of sorghum-Ogi with groundnut seeds also showed a significant increase in the protein, fat and ash content with increasing level of groundnut seeds [15].

Protein is one of the building blocks of life. It is a very essential nutrient which must be included in every day diet most especially in the diet of neonates; it helps to combat the adverse effects of malnutrition.

Table 2. Proximate analysis of sorghum-*Ogi* plantain blends

Samples	Moisture (%)	Ash (%)	Protein (%)	Fat (%)	Carbohydrate (%)
A	42.37 ±2.11	1.37±0.04	10.28±1.17	1.61±0.43	44.37±3.11
B	40.98±1.17	0.68±0.17	8.09±0.98	7.59±1.84	55.43±2.61
C	38.84±1.92	1.89±0.09	7.22±0.13	14.26±2.13	42.01±3.31
D	30.04±2.60	1.87±0.73	6.78±0.22	16.67±2.17	44.64±2.13
E	35.98±2.76	0.53±0.18	6.56±0.11	18.65±2.25	34.06±2.67
F	28.55±2.11	0.34±2.11	6.13±0.49	19.82±2.11	27.55±2.22

Protein helps neonates to form antibodies to fight infections, it helps to build, maintain and repair new tissues of all organs. Neonates develop rapidly in the first year of life and this rapid development is enhanced by protein synthesis. Ash content also represents the total mineral content in the food. There were fluctuations in the values gotten for the ash content in this study. Sample C (40%) fortified sample has the highest value which indirectly signifies a high mineral content. Fat is a major source of fuel for the body (it provides a lot of calories) and it is also the main way to store energy, this helps to support the growth rate of babies because they need lots of calories. Fats also help in the development of baby's brain, 60% of the brain and sheaths surrounding the nerves are actually composed of fat. Increasing addition of plantain flour significantly increased the fat content of the Sorghum-*Ogi* plantain flour blends. It is been known that foods that are rich in fats especially unsaturated fatty acids, tends to improve blood cholesterol, decrease risk of heart disease as well as help in weight loss.

3.2. Effect of plantain flour blending on the functional properties of Sorghum-*Ogi*

The pH of the sorghum-*Ogi* samples were found to range between 3.87 and 4.45 (Table 3). There was no apparent effect of plantain flour addition on pH of the entire blends.

Table 3. Functional properties of sorghum *Ogi*-plantain blends

Samples	pH	Titrateable Acidity (%)	Water Absorption Capacity (g/g)
A	3.87	0.23	14
B	4.10	0.20	15
C	4.04	0.25	17
D	4.30	0.09	18
E	4.20	0.24	18
F	4.45	0.26	11

There was increased value in the water absorption capacity parameter up to sample E while a decrease value from 18% to 11% was observed in 100% blend lesser than the control blend. It is known that the digestibility of starch is determined by high water absorption capacity [16]. The higher water absorption capacity values obtained for samples D and E suggest that plantain flour can be useful in food preparations that require hydration such as bakery products. There was no considerable effect on the titrateable acidity compared to the control, however, sample D, which is 60% plantain flour, showed a slightly lower value compared to other food blends.

3.3. Microbial analysis of Sorghum *Ogi* – plantain blends.

From Table 4, the coliforms tested for include *Escherichia coli*, *Klebsiella pneumoniae* and *Enterobacter aerogenes*. The fungi isolated which is yeast is *Saccharomycis cerevisiae* and no bacterial was found. The microbial result confirmed that the food blends are safe for consumption.

Table 4. Microbial analysis of sorghum *Ogi*- plantain food blends

Samples	Coliform Test
A	negative
B	negative
C	negative
D	negative
E	negative
F	negative

3.4. Taste- panel assessment of Sorghum *Ogi*-plantain flour blends

The quality attribute of the foods was evaluated by a Ten-man taste panellist using a 5-Hedonic parameter. Table 5 indicated that all the samples were above average and fit for consumption. From the mean values, it was observed that taste, appearance, texture, colour and the overall acceptance were above average and samples B and F are adjudged the best of all blends when compared with the control. The sensory analyses on both samples were sour, cloudy, thick, brownish red and the overall acceptance was very good which has the same parameters with the control sample.

Table 5. Average sensory analysis of Sorghum *Ogi*-plantain flour

Samples	Taste	Appearance	Texture	Colour	Overall acceptance
A	2.6 ± 0.3	4 ± 0.9	3.4 ± 0.2	2.7 ± 0.7	2.8
B	2.7 ± 0.1	4 ± 0.8	3.5 ± 0.2	2.5 ± 0.3	2.4
C	1.9 ± 0.1	4 ± 0.8	3.7 ± 0.6	2.6 ± 0.4	2.5
D	2.8 ± 0.2	4 ± 0.8	3.3 ± 0.6	2.5 ± 0.3	2.6
E	2.0 ± 0.1	4 ± 0.9	3.6 ± 0.4	2.5 ± 0.3	2.4
F	2.0 ± 0.5	4 ± 0.9	3.4 ± 0.8	2.6 ± 0.4	2.6

3.5. Effect of plantain flour on pasting properties of Sorghum-*Ogi*.

The result of the functional effect of Sorghum-*Ogi* fortification using plantain flour is shown in Table 6.

Table 6. Functional properties of Sorghum-*Ogi* plantain blends

Samples	Peak Viscosity	Trough	Breakdown	Final viscosity	Setback	Peak Time	Pasting Temperature
A	480	408	72	577	169	5.93	94.45
B	767	682	85	1095	413	6.13	92.05
C	1172	954	218	1271	317	5.93	62.65
D	1204	961	243	1284	323	6.00	88.85
E	1658	1258	400	1783	525	5.60	87.25
F	1709	1292	417	1829	537	5.47	86.35

The peak viscosity ranged between 480–1709 RVU. The capacity of starch to swell up freely before their physical break down is a measure of the peak viscosity [17]. The highest value was obtained in 100% substituted plantain flour, which suggests that it contains highest starch content since high peak viscosity is an indication of elevated starch content [18]. Peak viscosity increased with an increased quantity of plantain flour; hence, plantain flour not only enhanced high quantity of starch but also created

a functionality property when the blend is prepared as meal even though the water absorption capacity dropped at 100% incorporation.

The ability of paste to withstand breakdown during cooling is determined by the trough value which was in range of 1292–408 RVU for the blends. This is also a measure of stability of the starch content of the mixture [19]. This correlates well with the breakdown parameter with the control sample having the lowest breakdown value which is an indication that the control was more stable in hot condition [20]. Summarily, the stability in hot water of Sorghum-*Ogi* plantain flour decreased with increased addition of plantain flour. The final viscosity is a measure of the ability of the food blend to form a viscous gel or paste after the cooking process and cooling process [20]. Final viscosity values ranged between 1829–577 RVU from control to 100% fortification with sample F blend having highest value; hence, it is an indication that the sample will form compact gel after cooking and cooling. The setback value is also a great measure of the ability of cooked starch to harden on cooking which is caused by amylase retrogradation. The higher the setback value, the lower the retrogradation [21], [22]. It was observed that the setback value increased with increased fortification. There was no considerable difference in the values obtained for the peak time of the fortified samples compared with the control. The temperature at which there is a first evident viscosity is known as the pasting temperature. There is a relationship between water absorption capacity and pasting temperature; a high pasting temperature directly signify a high-water absorption capacity of the food blends and this is due to the association of the starch granules which are present in the food blend [23]. It was observed that the control was higher than other blends in terms of pasting temperature. The overall result of the functional properties implies that the preparation of the food will form well after preparation even though may not be stable at hot temperatures.

3.6. Mineral composition of Sorghum *Ogi*-plantain flour

The minerals distribution of the blended samples is indicated in Table 7. It was observed that 100% fortified sample had the highest Fe content which is an essential constituent of weaning foods.

Table 7. Mineral composition of Sorghum *Ogi*-plantain food blends

Sample	Zinc (mg/L)	Chromium (mg/L)	Iron (mg/L)
A	0.3773	0.0349	1.0801
B	0.3543	0.0129	1.4940
C	0.2389	0.0152	0.8072
D	0.2218	0.0163	1.1324
E	0.2108	0.0151	1.2289
F	0.1138	0.0113	1.1847

Iron (Fe) is an essential nutrient in diets especially in neonate diets because it is essential for the development of baby's brain; it helps in neurological and cognitive development. It is very important that babies consume a steady supply of adequate iron at every stage of growth. Iron deficiency may hinder the development of the central nervous system. Zinc is also an important mineral nutrient in the body; it helps in treating diarrheal episodes in children [24]. Deficiency of Zinc in diets can also lead to growth retardation. Zinc plays a major role in the immune system; it affects the cellular and humeral immunity [25]. Low level of Zinc in neonates also increases the risk of exposure of the infant to severe infectious diseases [26]. Chromium levels in the samples were very low and insignificant. The obtained values for Zn and Fe was lower when compared with previous work of Abioye and Aka [27] on fortification and hence can be seen that the food blend is safe for consumption.

4. Conclusion

In numerous parts of the world, protein-energy malnutrition continues to thrash populations resulting to high child mortality. There is a need to upgrade the nutritive content of weaning diets during the weaning time in respect to low energy density, bulkiness, low concentration of traditional diets and most especially, low protein and fibre quality used in weaning. The availability of various weaning foods may help to increase low protein and energy intake due to ordinary diets. The nutritional value of Sorghum-*Ogi* fortification with plantain in this study could be helpful as constituent of a staple, enriched diets formulation; thus enhancing the use of plantain flour applications in food industry.

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